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THE EVOLUTION OF THE GLOBE.

Geology: Earth History. By Thomas C. Chamberlin and Rollin D. Salisbury. Vol. ii., Genesis, Paleozoic, pp. xxvi+692. Vol. iii., Mesozoic, Cenozoic, pp. xi+624. (London: John Murray, 1906.) Price 21*s.* net each.

THE first volume of this important work, noticed in NATURE of January 19, 1905, and already in its second edition, dealt with geological processes and their results. In the two volumes now before us, which complete the work, geology is treated from the historical side, and we have a comprehensive review of the history of the earth on systematic lines. The treatment of these two formally separable branches of the science is, however, such as to emphasise the essential unity of the whole. As geological processes were discussed with continual reference to the historical application of the principles laid down; so the evolution of the globe, which is the story of these latter volumes, is regarded consistently from the causal point of view. Indeed, some subjects already considered under the head of geological processes, such as the dynamics of deformation, the causes of glaciation, &c., are now more fully discussed in connection with the particular geological periods which most clearly exemplify the phenomena.

The part of the work which will be read with greatest interest is that which falls under the subtitle "Genesis." Considering geology as "the domestic chapter of astronomy," the authors devote much more space than is customary in geological treatises to the problem of the origin and primitive condition of the globe. This is, we think, amply justified by the fundamental place which cosmogony necessarily occupies in the construction of the science. It is evident that opinion concerning such questions as the causes of crust-movements, the essential mechanism of igneous action, the origin of the atmosphere and hydrosphere, the beginning of life, must be controlled by the view adopted, formally or tacitly, of the mode of origin of the earth as a planet. Less obviously, but not less surely, some theory of the earth's initial state is involved in numerous geological doctrines, the dependence of which on such considerations is liable to be overlooked; and the authors do good service in recalling this fact repeatedly in the historical record which follows. The clear recognition of cosmogony as the foundation of geology, by revealing an unsuspected element of hypothesis at various places in the superstructure, offers a warning which is perhaps in some quarters not wholly unnecessary.

The special interest of this part of the book, however, lies in the first complete exposition of the "planetesimal" theory, which the senior author has already propounded elsewhere. That our solar system has in some manner been evolved from a nebula of some kind is an assumption to which few will demur; but the particular theory associated with the name of Laplace, and generally known as the nebular hypothesis, starting from a gaseous nebula of extreme tenuity, has for some time been felt to involve difficulties, which become more serious upon a closer examination. These difficulties are cogently stated by the authors, especial stress being laid on the great discrepancy which Moulton has pointed out from a consideration of the actual distribution of moment of momentum in the solar system. The meteoritic hypothesis, whether in Lockyer's or in Darwin's form, is held by the authors to be open to the same objections as the theory of a gaseous nebula, with which, indeed, it is practically identical as regards its more important consequences. According to the planetesimal hypothesis, the constituents of the system might be molecules or small masses of any kind moving in orbits about a common centre, the essential point being that their behaviour depended, not on mutual collisions (as on the meteoritic hypothesis), but on revolution in independent orbits. On this supposition there was, after the initial nebula was once formed, no fundamental change in the dynamics of the system, but only a progressive aggregation of the infinitesimal planetoids ("planetesimals") to form the planets and their satellites as they now exist.

The original nebula postulated was not a gaseous one, but belonged to the type giving a continuous spectrum, and had, like most of these, the spiral form. There were also, as in such nebulæ in general, knots of denser aggregation which became the nuclei of the several planets, though the greater part of the material outside the central helioid was still widely scattered. The manner in which such a system may have been developed from an ancestral helioid by the near approach of another star is tentatively pictured; but this is no essential part of the hypothesis, which is concerned, not with the whole evolution of the solar system, but with the birth and subsequent history of the planets. Starting with the conception of an infinitude of small masses revolving in different elliptic orbits of considerable eccentricity, with a certain degree of clustering already pronounced, the authors discuss the manner in which these planetesimals became aggregated into planets, moving in orbits of only small eccentricity, and with rotation in the same direction as the orbital revolution.

It is for the mathematician rather than the geologist to pass judgment upon this new treatment of the dynamical problems involved, but the geologist must be vitally interested in the verdict. The earth as built up on the planetesimal hypothesis will be a very different body from the earth as condensed from a gaseous spheroid, and must have passed through very different stages of evolution since it acquired individuality. The first-formed solid nucleus was probably devoid of any atmospheric envelope, its attraction being insufficient to control the rapidly moving molecules of gases. An appreciable atmosphere had probably been gathered when the growing globe had attained one-tenth of its present mass (being then comparable with Mars). The atmosphere would at first be collected from outside, but there was already a large quantity of occluded gases in the material built into the solid globe, which might eventually be

set free by extrusive agency, and continues to be a source of supply to the present time. The nature of the primitive atmosphere may be conjectured from the known occluded gases in crystalline rocks and meteorites, having regard also to a certain selective effect depending on molecular weights. Carbon dioxide was probably abundant and nitrogen only a minor constituent, the latter, in virtue of its chemical inertness, having accumulated progressively throughout subsequent time. It is supposed also that the oxygen in the present atmosphere has mainly been set free by the agency of vegetable life. The initiation of vulcanism is next considered, involving a discussion of the thermal conditions in the growing globe. The heat produced by the infall of the planetesimals was probably important only in the earlier stages of growth, and the chief source of the earth's internal heat is ascribed to the progressive compression of the central parts. It is estimated that this cause alone would suffice to reach the melting temperature of rock when the earth had acquired one-tenth of its present mass. On account of the originally heterogeneous composition of the globe, local spots of fusion would arise, the occluded gases presumably playing a part in the process, and, aided by the varying differential attractions of the sun and moon, the molten matter would gradually work its way outward. This action is supposed to be facilitated by "selective fusion," the more fusible materials encountered being taken up and the more refractory of the old materials deposited. In the general theory of igneous action developed by the authors there is evidently much that is debatable. In particular, the assumption that minerals have their melting points raised without limit by increased pressure, is one to which many physicists will demur. The maximum melting point found by Damien and others for various organic bodies, and considered by Tamman to be a general property, has led Arrhenius to very different conclusions concerning the actual condition of the earth's interior.

Another part of our authors' system which fails to carry complete conviction is the explanation offered for the initiation of the ocean-basins. The cardinal fact to be accounted for is the lower density of the crust in the continental areas as compared with that beneath the ocean floor. The difference is here attributed to the weathering and leaching action on the land, as contrasted with the relative protection of the rocks under the sea. It is supposed that the selective action of degradation and transportation sets up in time an appreciable difference in composition between the average material of the continental and that of the suboceanic tracts, the former becoming more acid and so lighter, and the latter more basic and therefore denser. The effect would be cumulative, and the difference of density established would be permanent, not being obliterated by subsequent metamorphism. In this way there might be evolved, from an originally fortuitous disposition of the growing hydrosphere, a distribution of land and water having a high degree of relative permanence.

We have dwelt on that part of the work which offers most of novelty, but the larger portion of the two volumes deals, on a more familiar model, with the several geological periods in order. The Archæan era is regarded as representing the climax of igneous action (or, as it is confusingly styled, volcanic action), and as being concurrently a time of intense crustal deformation. The Huronian and other pre-Cambrian formations which follow the Archæan are grouped as Proterozoic—an unfortunate choice, since the name has already been used by Lapworth for the Lower Palæozoic. The Lake Superior region is taken as the typical area, and three distinct systems are recognised —Huronian, Animikean, and Keweenawan. The great fossiliferous systems are then dealt with in turn, the chief innovations as regards systematic arrangement being the division of the Carboniferous into two, Mississippian and Pennsylvanian, and the separation of the Lower Cretaceous as a distinct system under the name Comanchean. Under each head the development of the stratified sequence in the North American continent is described and its interpretation discussed, the probable geographical conditions of the North American area at different periods being illustrated by maps. The corresponding strata of other parts of the world are dismissed more summarily. This plan is natural in a work designed primarily for American students, and its inconvenience is felt only in certain cases where the American record is incomplete or inadequate, especially in the Permian and Jurassic periods. We have, however, as a digression, a good account of the widespread glaciation in the southern hemisphere in Permian times, with excellent figures (after Schwarz) of glaciated rock-surfaces and boulder deposits in South Africa. We think that the authors have succeeded in giving a fairly complete and well-proportioned sketch of the earth's history in its successive chapters. The only serious defect which we find is the slight notice accorded to igneous action, and especially the failure (except in the earliest chapters) to recognise this as an essential part of geological history, closely bound up with the tectonic development of the globe.

For reasons connected with the curriculum of American universities, the history of life is treated in great measure apart from the physical history of the earth, a plan not without practical disadvantages. No attempt is made to give a complete "roll-call" of the flora and fauna of each period, but attention is directed especially to the main lines of biological development from the evolutionary standpoint. As regards the evolution of life in general, it is supposed that more than half of the complete history antedates the first fair record, offered by the Cambrian strata, in which we have abundant evidence of a development already far advanced. For this reason the Cambrian faunas are dealt with at some length. Similarly, in the Carboniferous we have for the first time a large mass of material bearing on the evolution of plant life, and this receives due notice, with a digression discussing the origin of coal and the climatic conditions implied in the profusion of vegetable life at that epoch.

The arrangement of the book is in most respects

well adapted to the requirements of students, and the presentation of the subject-matter is always clear. In the biological sections Transatlantic freedom of style is sometimes carried so far as to savour of the evening Press, paragraphs being headed, for example, "New Devices of the Bryozoans" and "The Protozoans make a Record." The abundant figures are well chosen, and, within the limitations of black and white, usually well executed, but the glazed paper, on which the whole is printed, is an offence to the sensitive eye. The work as a whole is one which will find a welcome in England as well as in America. The planetesimal theory, too, whatever its ultimate fate, is at least a spirited protest against any narrow limitation of geological time, and may serve to fortify timid geologists against the thunders of certain mathematicians, too apt to forget the precarious basis upon which their calculations are built. A. H.

THE GENESIS OF THE INVENTOR.

Erfindung und Erfinder. By A. du Bois-Reymond. Pp. vi+284. (Berlin: J. Springer, 1906.) Price 5 marks.

IN his opening chapter, Herr du Bois-Reymond gives an historical survey of the development of the Patent Laws in civilised countries. They date from the Act of Parliament passed in the year 1623, which in its first clause abolished the long-standing grievance known as monopolies, by which favoured individuals had the exclusive right to sell such things as salt and coal; the second clause established a new variety of monopoly, out of which patent rights had their origin. Little has been altered in principle since that date. Even down to the term of fourteen years the system still holds good, rights being granted to "any new manufactures." Other countries, adopting the idea at much later dates, attempted a more formal definition of invention, and legal logic has constantly tried to define the admissible and the inadmissible. Herr du Bois-Reymond shows that in Germany, since the year 1889, the number of patents granted has varied between 29 per cent. and 45 per cent. of the number of applications filed, and, therefore, assuming the quality of the inventions to be on an average the same from year to year, it would seem that the official mind is not yet certain in its workings.

The author's analysis of the nature of invention and inventors leads to the conclusion that neither need, nor chance, nor the lack of necessaries in surrounding life suffices to draw out the inventor. Instead of solving the problem by philosophic deductions from generalities, he descends to the particulars of the Patent Office, and concludes that inventors can be subdivided into three classes:—first, the intuitive genius, or, as Herbert Spencer would have said, the man who can do with little trouble that which cannot be done by the ordinary man with any amount of trouble; secondly, the technical man, well acquainted with his work, who follows in the wake of the intuitive genius, and is largely inspired by him; thirdly, the layman, whose special province seems to be feeding-bottles. We are inclined to think that too much stress can be laid on the existence and qualifications of the first class. A long series of inductive reasonings, followed generally by equally laborious experiment, is the usual course of a successful invention. Helmholtz and Darwin were not inventors, but their methods were the same. Helmholtz said that in his work he could only liken himself to the mountaineer, painfully and slowly climbing, often obliged to turn backwards, lighting later on new traces leading forward, and finally reaching the goal, only to find to his confusion that a plain road led thither, if he had only had the eyes to see. Darwin said he thought he was superior to the common run of men in noticing things which easily escape attention, and in observing them carefully. "My industry has been nearly as great as it could have been in the observation and collection of facts." Herein lies the real spirit of the pioneer. Nothing is more useful than the quality on which Darwin naïvely lays stress, viz. that of noticing things which escape attention; and those who hope to reach the promised land without wandering in the wilderness are probably doomed to disappointment.

Superficially, chance seems to play a large part; but Herr du Bois-Reymond maintains that chance only determines whether this or that individual shall do the deed, and has nothing to do with whether or not the deed shall be done. This is probably true in those cases in which attention is directed to a problem from various sides owing to a main directing cause. Such was the result of Moissan's discovery of the production of calcium carbide in the electric furnace. The acetylene generator seems to follow as a matter of course. Moissan had no heed for the commercial exploitation of such things, and many others, becoming aware of the existence of an obvious need, which appeared to be capable of being dealt with without the aid of the calculus, rushed in, left the relics of their labours in the files of the Patent Office, and discovered later that they were wholly unacquainted with the conditions of the problem. In this case mere inspiration leads nowhere; laborious experiment is much more to the point, and chance only comes in, having regard to the number of men at work on the task, in determining who shall lodge his application first. That cannot properly be called chance which is merely the outcome of some unlooked-for combination or slight variation of procedure; it is precisely for these things that the inventor toils, and when they come within his sight he merely recognises that for which he has patiently hoped.

Herr du Bois-Reymond concludes by considering the reaction on civilised life which is due to the existence of the inventor. The idea of protecting the inventor was only an indirect cause of the Patent Laws in most countries. A more direct impulse was probably given by the view that the prosperity of the State was likely to be increased by such encouragement as could be given to the creation of industries. Still, Faraday's commercial value has been incalculable, but he received little encouragement from Patent Laws, while